Biodegradation of endocrine disrupting compounds by bacterial communities from contaminated environments in Macau

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Endocrine disrupting chemicals (EDCs) is a group of a wide range of chemicals that can alter the hormonal and homeostatic systems of organisms. An increasing concern on possible human and environmental health effects of these compounds is due to the alarming evidence from scientific studies indicating negative effects in the reproductive system of aquatic species, wildlife, and humans as a result of exposure to very low (ng L^{-1}) concentrations [1]. There is a long list of chemicals with estrogenic activity, which include natural estrogens and synthetic or industrial chemicals such as bisphenol A, and more recently Bisphenol S. Incomplete removal of these chemicals in wastewater treatment plants lead to contamination of the receiving aquatic environment. The situation of The Pearl River Delta (PRD), also known as Guangdong—Hong Kong—Macau Greater Bay Area, is of particular concern due to the high industrialization and for being one of the most densely urbanized regions in the world [2,3].

In the present study, soil samples obtained near a discharge site of a sewage treatment plant and activated sludge samples collected from an aeration tank of the same station, located in Coloane, Macao, were used for the establishment of selective enrichments with bisphenol A (BPA), bisphenol S (BPS), 17β-estradiol (E2) and 17α-ethynilestradiol (EE2). Total removal of 3.5mg L^{-1} of E2 and EE2 and 15mg L^{-1} of BPA was achieved 21 days after starting the enrichment. For BPS, removal of 91% was observed in the enrichment from soil and 68% in the enrichment from activated sludge, fed with 15 mg L^{-1}, during 28 days. Removal includes degradation and adsorption to particles from soil and sludge. After two month enrichment, the consortia were able to completely degrade 10 mg L^{-1} of BPA in three days, while BPS was not degraded. For the hormones, degradation of E2 varied between 40 and 100%; degradation of EE2 varied between 36 and 77%, in 15 days. A total of 28 strains were isolated from the degrading consortia. The strains were identified by 16S rRNA gene sequencing and half of these were taxonomically affiliated with *β-proteobacteria*. Degradation of the compounds by the isolated bacteria was tested first on minimal agar plates and then in liquid media as sole carbon source. The maximum extent of degradation obtained was 67% for EE2 and 100% for E2, supplied at 4.5 mg L^{-1}, and 23% for BPA and 34% for BPS, supplied at 9.5 mg L^{-1}, during 28 days. The achieved degradation for BPS is particularly interesting, since this compound is considered recalcitrant to biodegradation and likely to accumulate in the environment. The isolated strains represent valuable candidates for in situ bioremediation of contaminated soils and waters. Promising results were obtained by a strain identified as *Castellaniella* sp. ED55, able to degrade the four compounds at different extents. Further studies are ongoing to optimize the degradation of the compounds by this strain and to deepen the knowledge about the mechanisms of degradation, including genome sequencing and transcriptomic experiments.

Keywords: Endocrine disrupting chemicals; biodegradation; Macau; enrichment; *Castellaniella* sp. ED55.

References

[1] K.L. Thorpe, R.I. Cummings, T.H. Hutchinson, M. Scholze, G. Brighty, J.P. Sumpter, et al., Relative potencies and combination effects of steroidal estrogens in fish, Environ. Sci. Technol. 37 (2003) 1142–1149. doi:10.1021/es0201348.
[2] X.-W. Chen, J.-L. Zhao, Y.-S. Liu, L.-X. Hu, S.-S. Liu, G.-G. Ying, Evaluation of estrogenic activity in the Pearl River by using effect-directed analysis, Environ. Sci. Pollut. Res. 23 (2016) 21692–21702. doi:10.1007/s11356-016-7377-7.
[3] E. Yamazaki, N. Yamashita, S. Taniyasu, J. Lam, P.K.S. Lam, H.B. Moon, et al., Bisphenol A and other bisphenol analogues including BPS and BPF in surface water samples from Japan, China, Korea and India, Ecotoxicol. Environ. Saf. 122 (2015) 565–572. doi:10.1016/j.ecoenv.2015.09.029.

Acknowledgements: I. S. Moreira wish to acknowledge a research grant from Fundação para a Ciência e Tecnologia (FCT), Portugal (Ref. SFRH/BPD/87251/2012) and Fundo Social Europeu (Programa Operacional Potencial Humano (POPH), Quadro de Referência Estratégico Nacional (QREN)). This work was supported by the Macao Science and Technology Development Fund (FDCT) through the project 011/2014/A1.